Headquarters Australian Defence Force

Derivation of the Manufacture to Target Sequence for Environmental Testing

by:

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SYNOPSIS

When new or modified explosives or explosive ordnance are being procured, the Australian Ordnance Council provides advice on their safety and suitability for service (S^3). This information is provided from the analysis of results from a program of tests designed to replicate the manufacture-to-target sequence of the explosive ordnance being procured. The manufacture-to target-sequence identifies the various environments the ammunition will experience from the time it is delivered from the manufacturer to the time it is fired and includes estimates of the time exposed to each environment and whether it will be packaged or not. This paper discusses the development of such a manufacture-to-target sequence and how it is then used in developing a suitable trial programme.

INTRODUCTION

1. The management of explosives and explosive ordnance of necessity requires consideration a whole of life cycle approach. The true costs of the equipment emerge when it is finally disposed of, whether that be an operational/training firing or as part of a disposal plan.

2. This paper will present a methodology for determining the environment to which explosive ordnance stores are exposed throughout their life cycle. The approach taken is to define a starting point and an end point, and then to fill in all the expected or credible way points that connect these two.

3. The Manufacture-to~Target sequence is a description of all the significant life cycle events which occur after an item has been manufactured and taken to the time the store is fired, functioned or otherwise disposed of. The sequence is drawn up after the various environments the ammunition will experience have been identified and includes estimates of the time exposed to each environment and whether it will be packaged or not.

4. The completed Manufacture-to-Target sequence is then used in conjunction with an environmental engineering analysis and appropriate risk and hazard analyses to develop a test

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plan designed to determine if the explosive store is safe and suitable for service use.

THE LIFE CYCLE

The Meaning of Life

5. The life of an item of explosive ordnance is regarded as being made up of 'storage' and operational' phases, which in total comprise the Service Life of the store as shown at Figure l.

6. Storage Life is defined as the time for which an explosive item, in specified storage conditions, may be expected to remain safe and serviceable.

7. Service Life is defined as the time for which an explosive item, in specified storage conditions and when subsequently used under its operational and/or training conditions, may he expected to remain safe and serviceable. This will normally be less than Storage Life.

8. Operational Life is defined as the time for which an explosive item may be expected to remain safe and serviceable when used under its operational or training conditions, when these are different from its storage condition, but which is within the envelope of its Storage Life.

Figure 1: The meaning of LIFE

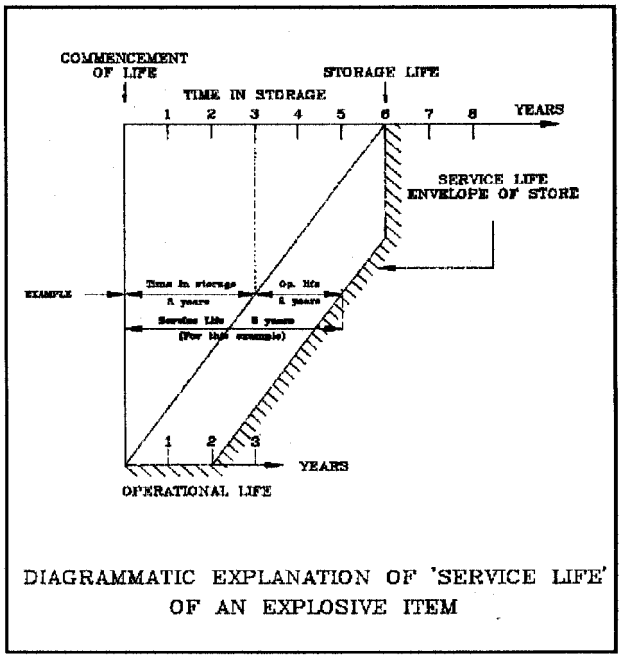

Figure 1: The meaning of LIFE

9. For the purpose of establishing an environmental profile the 'storage' phase of an item's life is taken to commence at date of filling, and may include storage by manufacturer prior to delivery, transport to major depot and all storage at major depots.

10. The 'operational' phase is taken to commence when an item leaves a major depot, and includes all subsequent deployment, interim storage (eg. storage at operational bases or in the field) and end use.

Where to Start?

11. If we are to develop a sequence which characterises the significant life cycle events, a good beginning would be a definition of the start and end points of the life cycle. The definition adopted by the Australian Ordnance Council (AOC) is to commence the assessment after the item or store has been manufactured. In other words, all manufacturing processes are complete, all manufacturers tests are done and the product has been packaged appropriately for the customer.
Consideration of issues such as storage by the manufacturer or immediate delivery to the customer come next, but the start point at least is well defined.

What is the Item in Question?

12. Before becoming too deeply involved in the life cycle events affecting the store, we must have an unambiguous statement of the design, configuration and packaging of the explosive store in question. This means we need the store nomenclature, description and all relevant drawings.

13. Does the store have detachable components? If so, are these at any stage to be stored/deployed in environments different from that of the main part of the store? At what stage of the store life cycle will they be assembled to constitute the complete store? Detailed consideration of the design of each component part and its role in the deployment of the store must be taken separately.

14. To complete our information on the store, we should note which of the armed services are likely to use it. This information usually presents interesting environmental considerations. For example, something to be used predominantly in the land service environment is normally packaged and designed with the typical army logistic support system in mind, including the typical private soldier who will probably be the end point user. In order to deploy the store, the army must also deploy the soldier using it. This then means sea, air and surface transport environments, to be taken singly or in combination.

15. Other examples are the management of an explosive store by one Service, but issue and use to another or all three Services. This typically occurs with demolition and small arms stores which are managed by Army for all three Services, but also sometimes occurs for guided weapons, such as lightweight torpedoes and Harpoon, which are managed by Navy but used by both Navy and Air Force. This multi-user aspect must be considered at the procurement phase so that appropriate tests can be specified for the differing environments.

Broadly, How Will It Be Used?

16. We are now in a position to consider some of the broader issues associated with the use of the store. We need to know the answers to the following:

- Is the store required to be water tight?
- If so, to what immersion depth?
- Is the store required to be hermetically sealed (ie. vapour tight)?
- Are desiccants included in the store?
- If so, what life is required of the desiccant?
- During which phases of the store life is desiccant required (eg. depot storage, transport, etc)?

  Is routine replenishment of desiccant intended?

- Is the store required to withstand changes in pressure due to changes in altitude?

- Is there a practice or blank version?

  If so, is it at any stage to be stored/deployed in environments different from that of the operational version? If so, due consideration must be given to each version.

- Are range safety templates required and are they available?

- Is the use of a land based Service firing range contemplated? If so, which ranges will be used for the operational version and which for the practice version, if procured?

- Is the UN Classification of this store known? If so, what is it?

- Is a UN Classification required? If yes, a completed application for UN classification (TGI 39) should be submitted.

- In which countries is the store manufactured? If manufactured overseas, account must be taken of overseas storage and transport to Australia.

- Is the store used by any other country? If so, which? (Obtain any available environmental or safety data from overseas sources.)

The Packaging

17. The ability of the packaging to prevent degradation of the store and protect it from harmful effects from the environment is an important consideration. Life cycle costs can be significantly affected by the performance of the packaging. Any examination of packaging for foreign sourced products must look carefully at the logistic system for which it was intended and compare that with the logistic support available at home. We have experienced expensive failures of weapons and their packaging transported 4,000 km across Australia by surface transport when that same weapon, designed and procured from the UK, was only ever packaged for trips of up to a few hundred kilometres at most.

18. Primary packaging is the smallest package unit, exclusive of integral casings, used to contain the store or stores. Secondary packaging is any packaging unit holding more than one primary package, and in which the primary packaged store spends a significant proportion of its life.

19. If a store does have packaging, then full details including drawings are required together with statements of when and where in its life cycle the store should be packaged and when unpackaged.

20. Depending on the product, there may be more than one level of packaging. If primary packaging is used, we must determine whether it is to contain the entire store, individual sections of the store or components of the store.

21. In some cases, primary packaging is intended for storage only, transit only or sometimes for both storage and transit. In Special cases, the packaging is in fact a launcher tube, box or is a multipurpose container.

22. Issues such as re-use or disposal after the store has been used and any other role the packaging is intended for must also be considered.

23. Some general matters to be resolved regarding the packaging include:

- Is the packaging required to be water-tight? If so, to what immersion depth?
- Is the packaging required to be hermetically sealed (vapour tight)?
- Is the packaging required to withstand changes in pressure due to changes in altitude?
- Is the packaged store to be handled/stored in larger units (eg pallets)? If so, details of the units, with reference to relevant drawings etc are required together with details on where these units enter the life cycle.
- Are desiccants included in the packaging? If so, what life is required of the desiccant?
- During which phases of the life cycle is desiccant required (eg depot storage, transport, etc)?
- Is routine replenishment of desiccant intended?

24. A salutary lesson on the role of desiccants was afforded a few years ago when a Tartar missile exploded shortly after launch. The cause was determined to be the failure to replace over-age desiccant and the result is shown at Figure I. Moisture was absorbed into the boost motor and caused cracking. The subsequent over-pressure on firing ruptured the motor case. Sections of unburnt sustainer motor can be seen in relief from the brightly burning boost motor and the shower of sparks from the igniter.

25. In any consideration of the life cycle, knowledge of the desired or expected life of the store is fundamental. A project manager may request a certain life time, but whether the product can achieve that may need to be determined through accelerated ageing tests. The requirement for life in storage and life in operational conditions must be stated.

26. A key determinant in the whether it contains any known short life items. It may be

necessary to replace items/components in order to achieve the minimum required life. On the other hand, it may be possible to extend the life by using additional protection either to the packaging or to the store itself. In any event, it is important to realise that there are stages in the life of the store where it is necessary to know whether, its life can be extended; the replacement lead time features strongly here, Ultimately, life extension is subject to In-Service Surveillance data and possibly some further testing.

Figure 2: Tartar missile failure due to over-age desiccant

Figure 2: Tartar missile failure due to over-age desiccant

27. Other factors having an impact on the life of the store include exposure to elevated temperatures, such as a round of ammunition held in a hot gun chamber or a fee extinguisher cartridge close to power plants in aircraft.

28. For some items, the effects of fungal growth on the store need to be considered.

29. Eventually, of course, the stores/explosive components become over-age; they should not be used operationally but may be safe to use in a training role. If not, then details of demilitarisation or disposal are required.

THE STORAGE PHASE

Storage by Manufacturer

30. The life of an item of explosive ordnance normally commences from the date of filling. Therefore, any time for which items are held by the manufacturer prior to sale/delivery must be included in the total storage life of those items.

31. When the manufacturer holds the store in stock prior to delivery to the user service, we not only need to know for how long may the store be held by the manufacturer prior to delivery, but also the conditions under which the store be stored by the manufacturer. Will it be air-conditioned (with temperature and humidity control) or is it temperature controlled only? Perhaps it is a good quality storehouse or just a thin walled storehouse; in each case, we must consider the storehouse temperature and humidity, the duration in storage, which geographic areas (eg. city, state, etc) and whether it has adequate ventilation.

32. A 'good quality' storehouse is one in which the inside temperature would be expected to remain reasonably constant over a 24 hour period, but would follow seasonal changes. It would normally be constructed of solid brick or similar material, and would have adequate natural ventilation.

33. A 'thin walled' storehouse is one in which the inside temperature would be expected to follow, but not exceed, daily fluctuations. It would normally be of light construction, with adequate ventilation, and must give complete protection from sun and rain.

34. If ventilation in a thin walled storehouse is inadequate, the inside temperature will exceed ambient when there is significant solar radiation. In this situation classification as 'unventilated' storage may be appropriate. However, it must be borne in mind that storage in such conditions may significantly shorten the life of the store. It may be necessary to obtain records of inside temperatures of typical buildings in the applicable climate before the appropriate storage condition can be selected.

Transport, Manufacture to Depot

35. At some point, the manufacturer will have to deliver the product to the customer. If this involves transport, then we must analyse all the transport modes the store is to experience.

36. For example, if the store be transported over sealed/unsealed roads, then we must know the maximum likely distance and in what type of vehicle this will occur. Details of what geographic areas are traveled and the estimated total time on vehicle (running and standing) are also required.

37. Other surface transport may involve rail travel. The maximum likely distance and likely geographic areas must be determined together with information on the estimated total time on rolling stock (running and standing).

38. For transport by sea, the maximum likely duration, through what geographic areas and whether the item will be as stowed cargo or deck cargo must be known; if deck cargo, the type of protection provided additional to the normal packaging (eg 150 container) should also be considered.

39. Transport by aircraft requires consideration of the type of aircraft, at what maximum altitude in unpressurised aircraft or pressurised aircraft and for what maximum duration.

Storage by the Customer Service (Depot Storage)

40. Ml the same considerations previously made for storage by the manufacturer must now be repeated, but this time from the perspective of customer storage.

THE MARITIME ENVIRONMENT

Transport, Depot to Ship

41. For deployment in the maritime environment, the store must first be transported from its storage depot to a particular ship. The same surface transport details for road and rail as required for transport from manufacture to depot are needed here, in the context of depot to ship transport.

42. Depending where the depot is, or indeed where the ship is in relation to the depot, the store may be transported by aircraft. If so, details regarding aircraft type, maximum altitude and the maximum duration in either pressurised aircraft or unpressurised aircraft must be obtained.

43. If the ship is at an anchorage, there may be a requirement to use a special means of transport such as a lighter or even a hovercraft.

44. In all cases, the maximum height that the store will be lifted above the wharf/bottom of vessel during loading/unloading (from lighter or wharf) is an important safety consideration.

45. Having got the store deployed, we should now consider its logistic cycle; if the store is likely to be returned to depot and subsequently re-issued, we should determine how many times is this likely to occur.

Figure 3: Getting it to the target

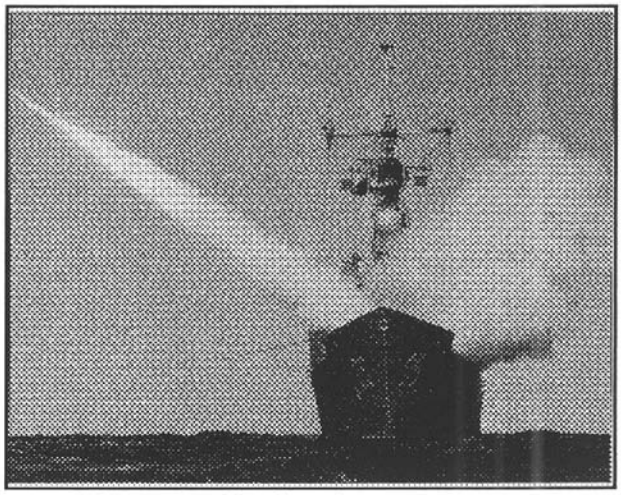

Figure 3: Getting it to the target

Storage in Supply Vessels, Troop Carrying Ships or Landing Ships or Craft

46. The conditions the store will be stowed during peace time exercises and operational conditions should be considered. In particular, whether the magazine is air-conditioned or merely forced draft ventilation; the duration it is stored and the magazine temperature and humidity; which geographic areas are involved; is it carried as deck cargo and what type of additional protection (eg 150 Container) is provided.

Transfer to/from Combat Vessel

47. If appropriate, the store may be transferred between vessels at sea by jackstay. It may be that the store is delivered by helicopter, either as an internal load or underslung; the maximum flight duration for this evolution must be determined.

48. All relevant information regarding transfer operations must be repeated for each class of combat vessel on which the store will be deployed.

Storage in Combat Vessel

49. In addition to the usual considerations of air-conditioned magazines, duration of storage, magazine temperature and humidity and the other matters as detailed above for supply ships, combat vessels require special consideration of the conditions the store will be stowed during peacetime exercises and operationally. For example, fitted storage facilities other than magazines (eg ready use deck lockers) may be employed and their position on/in ship taken due account of. Within the storage enclosure, the climatic conditions must be determined.

50. For some stores, the risk to the ship can be reduced by improving the stowage; when in a magazine or other storage position, the store may be stowed horizontal, vertical, it might be fore-and-aft or athwartships, in purpose designed racking and above or below the waterline.

Deployment on Launcher, Gun or Other Weapon System

51. A 'launcher, gun or other weapon system' includes any deployment device on or in which the store is held prior to delivery. Devices such as depth charge racks, grenade launchers should be included. How long the store remains on this weapon system at any one time or as a cumulative total during its life in service must be determined.

52. Deployment in which geographic areas should be stated and whether the store will be exposed to solar radiation, wind, precipitation (including ice), salt spray or water immersion.

53. It may be required to assess whether the store will perform safely when fired through raln/hail/sleet/snow.

54. Modern loading systems put considerable mechanical stress on the ordnance and so the question of what is done with unused stores down-loaded from the weapon system must also be addressed. If unused stores are recycled, the maximum number of times a store is likely to be placed on standby in the weapon system should be stated.

Other Combat Vessel Storage or Operational Conditions

55. Other conditions to be considered are whether the store is to be stowed or operated on or adjacent to a flight deck or helicopter landing pad; in some ships it may be near a designated vehicle park.

56. Shock or gun blast in any position on the ship are hazards of varying severity, while the hazard associated with dropping an explosive store in the ship requires careful analysis, including all possible drop heights, whether packaged or not and disposal of dropped stores.

57. If the store is to be launched from submarines, the depth of launch/operation is to be specified.

58. If the store is a sea mine, then information on how it will be tethered or whether it is to be free floating, what the maximum operating depth is and how will it be laid are essential. The mine may have a requirement for laid operational life and it may be required to be operational in certain geographic areas. Neutralising and sterilising options are essential; the store should be self sterilising and the 'rendersafe' requirements clearly stated together with intentions regarding whether to recover/clear the mine after rendering safe.

59. If the store is to be used as a helicopter weapon, full consideration of the Air Service Environment is required.

LAND SERVICE ENVIRONMENT

Transport, Depot to Unit

60. The considerations for transport here are the same as those for transportation from the depot to a ship in the maritime environment.

6l. In addition, the store may be delivered by helicopter, either as an internal load or underslung. If the store is to be air dropped, the method of delivery and any protection provided, additional to that described above as packaging, should be noted.

62. The store mazy be transported by amphibious vehicle, including hovercraft. Each vehicle type must be treated separately and the maximum likely distance, the geographic areas, the type of terrain and the estimated total time on vehicle (running and standing) are to be stated.

63. If the store is to be transported from depot to unit by any other means, give details. if the store is likely to be returned to depot and subsequently re-issued, how many times this is likely to occur should be stated.

Storage, Unit

64. Unit storage conditions during peacetime exercises and operational conditions must be assessed. The guidelines given for assessing storage by the manufacturer can be used here and put in the context of storage by an Army unit. The type of storehouse and its location will have to be defined for the various units.

Field Deployment

65. The geographic areas the store is likely to be deployed in the field during both peacetime exercises and operational conditions must be ascertained.

66. There are considerable transport factors influencing land service deployments. When the store is carried in surface vehicles, each vehicle type must be analysed for stowage configurations such as horizontal, vertical, along front, rear or sides, in purpose designed or ad-hoc racking.

67. The maximum distance for which the store will be carried, over what type of surface and for how long (expressed as a maximum single trip and as a cumulative total during its life in service) all need to be stated.

68. When the store is carried by a soldier on foot, we must be aware of the means of handling the store, including any special packaging additional to that already described. The maximum distance for which the store will be carried at any one time and as a cumulative

total during its life in service should be given.

69. Where a launcher, gun or other weapon system is used a description of the weapon system is required and all storage, transport and handling queries addressed for each type of weapon.

70. Exposure to solar radiation, wind, precipitation (including ice), dust or sand are all hazards in the land service environment. In addition, the store is likely to be held in the field during peacetime exercises and operational conditions, exclusive of periods spent in operations, in unventilated temporary storage eg canvas or containers affording direct cover from sun and rain (including storage on vehicles). On the other hand, it may be afforded no climatic protection (including storage on vehicles).

71. It may be required to assess whether the store will perform safely when fired through rain/hail/sleet/snow or foliage. The requirement here must be stated.

72. What is done with unused stores returned from field deployment? If unused stores are to be recycled, the maximum number of times a store is likely to be deployed in the field needs to be decided.

73. Handling accidents, especially dropping, must be examined in all scenarios involving the soldier and the store; the maximum possible drop height, whether a vehicle is involved, the state of packaging and action to be taken with dropped stores are all factors for consideration.

74. Where the store is a land mine, the method of laying and the requirement for laid operational life must be stated. In addition, what geographic areas are required for the mine to be operational, under what soil conditions is it required to be laid and for what duration should also be given, together with the 'render-safe' requirements.

75. If the store is to be used as a helicopter weapon, consideration of the Air Service Environment is required.

AIR SERVICE ENVIRONMENT

Transport, Depot to Unit

76. The considerations for transport here are the same as those for transportation from the depot to a ship in the maritime environment and depot to unit in the land service environment.

Storage, Unit

77. Unit storage conditions during peacetime exercises and operational conditions must be assessed. The guideline given for assessing storage by the manufacturer and unit storage in the land service environment can be used here and put in the context of storage by an Air

Force unit.

Deployment on Combat Aircraft

78. Deployment on combat aircraft might require that the store be transported to the aircraft on weapon trolleys. If so, what type of surface is involved and are the trolleys unsprung? The type of protection, if any, provided for the store and the maximum duration of any waiting time on trolleys exposed to the weather should be known.

79. How and where the store carried on the aircraft is a paramount consideration. If the store is an 'Aircraft Installed' device, the required installed life should be stated. The resultant mechanical environment, known or specified as a requirement, must then be detailed. Vibration (including gunfire), shock (airborne and landing, aircraft carrier operations), acceleration (on the aircraft and on launch) and emergency arrested landing must all be accounted for.

80. The geographic areas the store is required to remain fitted to the aircraft on the ground/flight deck and the maximum time that the store is required to remain fitted at any one time or as a cumulative total during its service life must be determined.

81. The usual climatic and environmental considerations of solar radiation, wind, precipitation (including ice), salt spray, dust or sand, while fitted to the aircraft, on the ground/flight deck.

82. If the store can experience accidental drop during handling on the ground, then we should list for each case the maximum possible drop height, the package state and action to be taken with dropped stores.

83. During operational and training flights, the flight profiles for the aircraft in which the store will be carried should be stated in terms of duration and altitude. The total required flying time in hours of the store when carried by its parent aircraft and what temperature extremes to which the store is likely to be exposed during operational and training flights (including the effects of aerodynamic heating, and ambient temperatures at high altitudes) are required.

84. Any environmental protection provided for the store while fitted to the aircraft in flight should be noted. Intentions that the store be fitted when the aircraft is deployed away from its base (eg involving long ferry flights) require determination of the likely cumulative flight duration and the maximum flight altitude.

85. The store may be required to perform safely when fired through rain, hail/sleet/snow; after a sortie, unused stores down-loaded from the aircraft must be dealt with. If unused stores are recycled, the maximum number of times a store is likely to be placed on standby in the aircraft must be known.

86. Unusual events require careful assessment; the response of the store to events such as a controlled emergency landing, crashes under attempted control, crashes out of control and whether jettisoned stores remain safe are all included.

ABNORMAL HAZARDS/EVENTS APPLICABLE TO ALL STORES

Fire

87. Is the store stored/deployed in positions where it could be exposed to a liquid fuel fire, other type of fire impinging directly on the store or its packaging or a fire in an adjacent compartment. If so, details of location, principle materials which would be involved in a fire, and store configuration must be given.

88. In the event of the store being involved in a fire, it is required to know the likely response of the store, how much time is likely to be available for fire fighting or other emergency measures, are there any known hazards associated with involvement of the store in a fire (eg toxicity of vapours, smoke) and are there any other special fire fighting considerations.

Impact/Shock

89. It is usually required to know the effects on a store in either the packaged or unpackaged state, of bullet impact, fragment impact, blast, shock, shaped charge jet and sympathetic detonation. If so, the anticipated hazard and relevant storage/ deployment configurations are to be detailed.

Premature Functioning

90. If it is required to know the effects of a premature functioning of a store, in either the packaged or unpackaged state, upon other explosives stores in the vicinity then details of each applicable configuration and means of initiation are required.

Nuclear Environment

91. It may be required to know the effects on the store in the packaged or unpackaged state of Gamma Rays, X-rays or Electromagnetic Pulse (EMP).

Electromagnetic Environment

92. It is often required to assess the response of the store in the packaged or unpackaged state to the effects of electrostatic charge, lightning, the Service electromagnetic environment or the induction of transient energy. Techniques for performing a theoretical analysis are available and these may be complemented by practical tests where possible.

CONCLUSIONS

93. The approach outlined in this paper provides a comprehensive life cycle profile of explosive stores entering the land, air or maritime service environments.

94. The large amount of information required to develop the manufacture-to-target sequence, suggests the need for a questionnaire-based approach. This has in fact been the case and an Environmental Questionnaire is used to elicit responses which are used for planning the necessary environmental tests.

95. The Environmental Questionnaire suffers from the obvious limitations of any system based on polling techniques. The utility of the results is directly proportional to the veracity and relevance of the answers. Unfortunately, no one person or organisation has all the answers needed and so the polling must be conducted across functional lines and often among all three armed forces. Notwithstanding these limitations, the technique provides valid data on which to base a test plan.

96. A summary of the main features of the approach is given at Table l. Even cursory examination of this table shows a large disparity in the approach to the maritime environment when compared with the land and air service environments. The air service environment is limited to considerations of combat aircraft whereas many explosive stores are carried in transport aircraft and other non-combatant aircraft. Similar restrictions appear in the examination of the land service environment; in both cases, care must be exercised when polling for information. A too limited view can seriously skew the resultant test plan and omit important tests for service in particular environments. Equally, a too broad a view will result in expensive overtesting of the product.

97. A possibility currently being examined by the AOC is to block-classify explosive stores and apply a generic environment for that particular classification. The environmental test plan can then be tailored to suit the particular store. This process is not intended to eliminate polling; rather, it will quickly and accurately establish a paradigm from which the final test plan can be drawn. It is therefore intended to be taken in conjunction with polling.